
***In vivo* determination of root canal length: a preliminary report using the Tri Auto ZX apex-locating handpiece**

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Abstract

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Aim The aim of this study was to assess the clinical performance of a cordless handpiece with a built-in apex locator – the Tri Auto ZX – designed for root canal preparation with nickel-titanium rotary files.

Methodology Twenty-five human maxillary incisor and canine teeth scheduled for extraction with mature apices were selected for the study. Informed written consent was obtained from each patient before treatment. After administration of local anaesthesia, the teeth were isolated and the pulp cavities accessed. The Tri Auto ZX along with a size 15 K-file was used in its electronic apex locating function based on the manufacturer's recommendations. A periapical radiograph with the file at the electronically determined constriction was taken, the file removed and the measurement registered as the electronic length (EL). To test the auto reverse function, a size 20 ProFile .04 taper NiTi rotary instrument was mounted in the handpiece. The point for the auto apical reverse function was preset on the panel at the 0.5 mm level. After the file was introduced into the canal and reached the predetermined level, the file automatically stopped and rotated in the opposite direction. A reference

point was marked and this measurement was registered as the auto reverse length (ARL). All measurements were made twice by two different investigators. Teeth were then extracted and immersed in a 20% formalin solution for 48 h. After fixation, a size 15 file was inserted into the canal to measure the actual root canal length from the same reference point obtained with the Tri Auto ZX to the apical foramen, as seen in the stereo microscope. When the file tip was visible at the anatomical end of the canal it was withdrawn 0.5 mm and this measurement was registered as the actual length (AL). All measurements were expressed in mm and the measuring accuracy was set to 0.5 mm. The significance of the mean differences between EL and ARL and between EL and AL measurements at the 5% confidence level was evaluated.

Results EL measurements were coincident to ARL in all instances. EL and ARL were coincident to AL in 10 (40%) canals, in the remaining 15 canals (60%) the AL measurements were longer than EL and ARL (+0.5 mm) in 14 instances and shorter (–0.5 mm) in one case. Overall, the AL was longer than the EL or ARL, the mean difference being $-0.23 \text{ mm} \pm 0.32$ ($P < 0.05$).

Conclusions It was concluded that the Tri Auto ZX was useful and reliable. The Tri Auto ZX measurements protected against overpreparation.

Keywords: apex locator, root canal length.

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Introduction

The use of electronic devices to measure the length of root canals and to locate the position of the apical

foramen has progressed substantially in recent years and has gained popularity. Unfortunately, many devices are inaccurate in root canals that contain moisture, vital pulp tissue, blood and other exudates or remnants of intracanal irrigants (McDonald & Hovland 1990, O'Neill 1974, Trope *et al.* 1985). Recently, the 'ratio method' for measuring root canal length was introduced (Kobayashi & Suda 1994). In this method, the quotient

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of two simultaneously measured impedances of two different frequencies is calculated to reveal the position of an electrode (an endodontic file) inside the root canal. The latest generation of apex locators are based on this principle and have many advantages when compared to earlier devices, especially because these instruments are reliable in both dry and wet canals (Christie *et al.* 1993).

The Tri Auto ZX (J. Morita Co., Kyoto, Japan), is a cordless handpiece with an integrated apex locator and designed for rotary canal preparation with nickel-titanium instruments based upon the same principle. This device does not require calibration because a microprocessor corrects the calculated quotient and the position of the file tip is showed on the panel. The functions and particular characteristics of use of the Tri Auto ZX were extensively described in previous publications (Kobayashi 1997, Kobayashi *et al.* 1997). *In vitro* studies (Campbell *et al.* 1998, Grimberg *et al.* 1998) have demonstrated that the Tri Auto ZX can accurately measure the root canal length and trigger reversal of file rotation when the instrument reaches a predetermined level. This also occurs when an excess of torque is registered. The apical extent of the instrumentation can be then more safely controlled (Zmener *et al.* 1999). The purpose of this study was to assess the clinical performance of the Tri Auto ZX.

Materials and methods

Twenty-five human maxillary incisor and canine teeth with mature apices were selected for study; all had been scheduled for extraction. Informed written consent was obtained from each patient before treatment. The patients consisted of 18 males and seven females with an age range of 22–60 years. Patients that used heart pacemakers or had a contributory medical history were excluded. A standardized periapical radiograph was taken of each tooth. A data sheet was used for recording the pulpal and periapical status, presence or absence of periapical radiolucencies, presence or absence of resorptive areas and exudate in the root canals. After the administration of local anaesthesia, each tooth was isolated and the pulp cavity accessed using a tungsten carbide bur rotating in a high-speed contrangle handpiece under abundant water spray. The entrances of the canals were irrigated with 2.5% NaOCl solution and dried by aspiration. In teeth with more than one canal, only the most accessible canal was used for the study. No attempt was made to clean debris or pulp tissue remnants prior to introducing a size 15 K-file (Dentsply Maillefer, Ballaigues, Switzerland) into the canals.

The Tri Auto ZX was first used as on electronic apex locator based on the manufacturer's recommendations. The lip-clip electrode was applied to the patient's lip and connected to the file. The size 15 K-file was advanced apically into the canal until the beeping sound and the red light emitting diode (LED) marked APEX on the panel began to glow, indicating that the tip of the file had reached the anatomical end of the canal in the periodontium. The file was then withdrawn with a slow counterclockwise turn until the red LED APEX light went out, suggesting that the tip of the file was at the predetermined length of the apical constriction. At that time, the 0.5 mm green LED light illuminated and a new beeping sound was heard. The file was kept in place by packing the access cavity with sticky wax. The silicone stop of the instrument was then moved to the reference point and a periapical radiograph taken, the file was removed from the canal and its length registered as the electronic length (EL). To test the auto reverse function, the sticky wax was removed from the access cavity and a size 20 ProFile .04 taper NiTi rotary file (Dentsply Maillefer) was mounted in the handpiece. The point at which the auto-apical reverse function triggered was preset on the panel at the 0.5 mm level. When the file was introduced into the canal, it begun to rotate automatically. The file was then advanced down the canal without exerting excessive force. When the tip of the file reached the predetermined level, a beeping sound was heard, and the file automatically stopped and rotated in the opposite direction. At this point the rotation was stopped. The length was marked with a silicone stop and the file was removed from the canal. The distance from the file tip to the silicone stop was then measured to an accuracy of 0.5 mm and registered as the auto reverse length (ARL). After use in one canal, the rotary and manual instruments were discarded.

Teeth were then extracted and immersed in a 20% formalin solution for 48 h. After fixation, they were stored for another 48 h in 2.5% NaOCl solution and then cleaned to remove all organic debris and deposits from the root surfaces. A size 15 K-file was inserted into the root canal to measure the actual root canal length from the same reference point to the apical foramen under $\times 15$ magnification in a stereomicroscope. When the file tip was visible at the end of the canal, it was withdrawn 0.5 mm, a silicone stop placed as the reference mark and the file removed from the canal; the distance from the tip to the silicone stop was measured to an accuracy of 0.5 mm and registered as actual length (AL). When the foramen deviated from the main axis of the tooth, the distance between the upper and lower borders of the

foramen was considered as the reference point of the anatomical apex location. All measurements were expressed in mm and completed by two different operators using a metallic endodontic rule (Maillefer). If differences were noted a new measurement was made by the first operator and a consensus reached. Paired *t*-tests were used to statistically analyze the significance of the mean differences between EL and ARL and between EL and AL measurements at the 5% confidence level.

Results

Clinical and radiographic evaluation of preoperative status revealed that five teeth were not responsive to hot and cold or to an electric pulp tester. Of these teeth, one had a periapical radiolucency. EL measurements were coincident to ARL in all instances. When compared with AL, both EL and ARL were found to be coincident on 10 (40%) occasions. In the remaining 15 canals (60%), the AL measurements were longer than EL and ARL (± 0.5 mm) in 14 instances and shorter than EL and ARL (± 0.5 mm) in one case. On average, the AL was longer than EL or ARL and the mean difference was $-0.23 \text{ mm} \pm 0.32$ ($P < 0.05$) (range -0.06 and -0.41).

Discussion

The performance of the Tri Auto ZX gave similar results to those obtained in previous studies (Campbell *et al.* 1998, Grimberg *et al.* 1998). The device operates on a ratio method designed to locate the narrowest diameter of the root canal which is regarded as being coincident with the apical constriction (Kobayashi & Suda 1994). As has been previously noted (Kobayashi 1997, Kobayashi *et al.* 1997) the 0.5 mm LED indicator is meant to correspond to the apical constriction. It is generally accepted that the preparation of a root canal should ideally be performed to this position (Nguyen *et al.* 1996). Earlier observations (Kuttler 1955, Nahmias *et al.* 1983), showed that when a file tip is 1 mm short of the anatomic apex, it will be within a range at which the apical constriction is generally located. Therefore, we felt appropriate to subtract 0.5 mm from the total length of each tooth to measure the AL, as seen with the stereomicroscope. Our observations revealed that the EL and ARL values given by the Tri Auto ZX were coincident or 0.5 mm different to AL which is normally considered to be a clinically acceptable difference (Fouad *et al.* 1990, Frank & Torabinejad 1993, Fuss *et al.* 1996). In one case EL was found to lie beyond AL. This was unexpected because the red light emitting diode should have illuminated. Radiographic evaluation of this

case revealed a periapical radiolucency. Careful observation of the extracted tooth with the stereomicroscope revealed a wide apical foramen surrounded by areas of internal–external root resorption. Previous observations (Nguyen *et al.* 1996) have indicated that the accuracy of electronic measurement were not affected by a wide apical foramen. However, because the values registered by the two independent investigators were coincident, an explanation for this particular case could be that the measurement procedure could be affected by areas of root resorption.

The accuracy of the ARL function was also tested because during canal preparation, this automatically activated function could prevent accidental overpreparation. As it was previously demonstrated, overprepared and overfilled root canals may decrease the success rate of endodontic therapy (Seltzer *et al.* 1973). In this respect, the ARL function was very useful and reliable, especially because EL and ARL measurements were coincident in all instances.

The preoperative status of the pulp or the presence of moisture and other contaminants within the lumen of the root canal did not appear to affect the behavior of the Tri Auto ZX. These characteristics along with its relative ease of operation, and its usefulness for canal preparation (Kobayashi 1997), suggest that under the conditions of this study, the Tri Auto ZX constitutes a valuable adjunct in clinical endodontics and shows great promise. However, studies on its accuracy over a more representative number of canals with a varying degree of clinical conditions are essential.

Conclusions

Firstly, the EL and ARL were coincident in all instances. When both EL and ARL were compared with AL, the values registered were either coincident or different in ± 0.5 mm from the AL ($P < 0.05$). Secondly, the Tri Auto ZX system protects against overpreparation.

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